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ABNORMAL SUMMERS IN THE UNITED STATES

By ALFRED J. HENRY

For several years past the public prints have carried predictions that the years 1926 and 1927 might see a return of the summerless year 1816, a year which according to the same authority was a calamitous one to the farmers in the United States and elsewhere on the continent of North America.

The purpose of this paper is to present the known facts concerning the severity of the summer of 1816 and to allocate the summers of 1926 and 1927 to their proper rank among the summers of the nineteenth century.

At the outset the summer of 1926 may be dismissed as an average one without distinguishing features of note. The summer of 1927, on the other hand, was out of the ordinary run of summers and by summer is meant the months of June, July, and August. June, 1927, was cool in the north and warm in the south about in the proportion, areas considered, of 1 to 1; July was close to normal, being slightly below in some areas and above in others.

August, due to an excess of cloudiness causing low day temperatures, had a monthly mean that for a large part of the Northern and Central States east of the Rocky Mountains must be classed as one of the coolest months of the name in the last fifty-odd years. So much for the three single months of the 1927 summer.

The mean temperature of the summer season is found by taking the mean of the three summer months; thus, using Washington, D. C., as an example, the mean of June was 68.6°; July, 76.4°; August, 70°; mean for the summer; 71.7° or 3° below the normal for Washington. If, however, the astronomical summer be considered—June 21 to September 23—the depression below the normal is but 1° F.

I have computed and placed on record, for use in the years that are to come, the mean summer temperatures at 25 representative stations throughout the United States, including in this group the records for New Haven, Conn., and New Bedford, Mass., two stations that have the distinction of possessing fairly homogeneous temperature records going back more than 100 years; both include the record of the year 1816 and thus afford the unique opportunity of comparing the temperatures as observed at those stations in that year with those observed in subsequent years.

The summers have been arranged in the order of magnitude of the abnormality in each of the two groups, cool and warm summers, respectively, and are shown in Table 1 below.

TABLE 1.—*Departures from the normal of the mean summer temperatures in the coolest and the warmest summers, respectively, at 25 representative stations in the United States*

No.	New Haven, Conn. (100 years)				New Bedford, Mass. (100 years)				St. Louis, Mo. (90 years)				St. Paul, Minn. (107 years)				New York City (55 years)			
	Cool		Warm		Cool		Warm		Cool		Warm		Cool		Warm		Cool		Warm	
	Year	Depression	Year	Excess	Year	Depression	Year	Excess	Year	Depression	Year	Excess	Year	Depression	Year	Excess	Year	Depression	Year	Excess
1	1816	−4.2	1876	4.8	1816	−4.8	1825	3.2	1915	−4.4	1891	5.4	1842	−5.9	1830	5.2	1903	−2.6	1901	3.3
2	1903	−3.9	1831	3.2	1836	−3.6	1831	3.2	1863	−3.1	1914	3.7	1915	−4.5	1821	4.0	1886	−2.1	1900	2.8
3	1817	−3.0	1877	3.1	1837	−3.1	1906	2.6	1875	−3.1	1854	3.4	1844	−3.9	1894	3.9	1897	−2.0	1872	2.3
4	1836	−3.0	1864	2.8	1903	−3.1	1876	2.3	1904	−3.1	1913	3.4	1860	−3.7	1921	3.9	1915	−1.9	1906	2.2
5	1859	−2.8	1828	2.3	1891	−2.7	1820	2.1	1839	−2.9	1881	3.3	1863	−3.7	1901	3.8	1881	−1.7	1892	1.9
6	1837	−2.4	1825	2.3	1842	−2.5	1838	2.0	1889	−2.7	1837	2.7	1843	−3.4	1823	3.7	1926	−1.4	1908	1.9
7	1857	−2.4	1880	2.3	1890	−2.5	1911	2.0	1842	−2.6	1887	2.7	1859	−3.4	1850	3.5	1916	−1.2	1876	1.5
8	1832	−2.2	1841	2.2	1829	−2.3	1912	2.0	1910	−2.5	1921	2.4	1865	−3.4	1828	3.3	1885	−0.9	1894	1.5
9	1902	−2.2	1845	2.0	1893	−2.3	1854	1.9	1848	−2.2	1871	2.3	1866	−3.1	1825	3.2	1914	−0.9	1899	1.5
10	1833	−2.1	1870	1.9	1822	−2.2	1909	1.9	1891	−2.2	1850	2.1	1924	−3.0	1838	3.0				
11	1869	−2.1	1875	1.8	1832	−2.2	1819	1.6	1912	−2.3	1918	2.1	1862	−3.0	1900	3.0				
12	1886	−2.1	1878	1.8	1839	−2.1	1865	1.6	1855	−2.1	1858	2.0	1891	−2.9	1822	2.9				
13	1890	−1.9	1871	1.6	1888	−2.1	1880	1.6	1883	−2.1	1864	2.0	1848	−2.7	1829	2.9				
14	1891	−1.9	1813	1.5	1902	−2.1	1877	1.5	1882	−2.0	1874	2.0	1904	−2.7	1881	2.9				
15	1835	−1.7	1863	1.4	1904	−2.1	1828	1.4	1852	−1.8	1839	1.9	1861	−2.6	1834	2.8				
16	1889	−1.7	1838	1.3	1833	−2.0	1900	1.2	1924	−1.8	1899	1.8	1869	−2.5	1889	2.5				
17	1897	−1.7	1868	1.3	1881	−1.9	1910	1.2	1849	−1.7	1867	1.7	1903	−2.5	1856	2.4				
18	1843	−1.6	1879	1.3	1884	−1.8	1818	1.1	1906	−1.7	1900	1.7	1912	−2.3	1827	2.3				
19	1907	−1.6	1900	1.3	1841	−1.7	1826	1.1	1917	−1.5	1872	1.5	1917	−2.3	1826	2.1				
20	1904	−1.5	1847	1.2	1873	−1.7	1856	1.0	1859	−1.4	1894	1.4	1867	−2.2	1854	2.1				
21	1824	−1.4	1840	1.1	1889	−1.7			1847	−1.4	1919	1.4	1902	−2.1	1853	2.0				
22	1827	−1.4	1901	1.1	1814	−1.6			1837	−1.3	1922	1.4	1847	−2.0	1878	2.0				
23	1858	−1.4	1908	1.1	1851	−1.6			1884	−1.3	1925	1.3	1849	−2.0	1831	1.9				
24	1884	−1.3	1865	1.0	1864	−1.5			1877	−1.2	1844	1.2	1875	−2.0	1852	1.9				
25	1815	−1.2			1844	−1.4			1888	−1.2	1856	1.2	1837	−2.0	1893	1.8				
26	1852	−1.2			1859	−1.4			1896	−1.2			1907	−1.5	1846	1.7				
27	1860	−1.2			1866	−1.4			1903	−1.2			1897	−1.4	1833	1.5				
28	1881	−1.2			1869	−1.4			1908	−1.2			1836	−1.4	1874	1.5				
29	1853	−1.1			1874	−1.4														
30	1905	−1.0			1886	−1.4														
1927		−1.1				−1.2				−3.2				3.5				−2.4		

TABLE 1.—*Departures from the normal of the mean summer temperatures in the coolest and the warmest summers, respectively, at 25 representative stations in the United States*—Continued

No.	Philadelphia, Pa. (55 years)				Baltimore, Md. (56 years)				Washington, D. C. (56 years)				Lynchburg, Va. (54 years)			
	Cool		Warm		Cool		Warm		Cool		Warm		Cool		Warm	
	Year	Depression	Year	Excess	Year	Depression	Year	Excess	Year	Depression	Year	Excess	Year	Depression	Year	Excess
1	1903	−3.0	1900	3.0	1907	−3.5	1870	5.2	1907	−3.2	1872	3.9	1907	−2.4	1881	3.6
2	1907	−1.7	1901	2.1	1903	−3.3	1872	3.1	1903	−3.0	1876	2.6	1889	−1.9	1900	2.3
3	1884	−1.5	1876	1.8	1891	−3.2	1876	1.8	1886	−2.3	1900	2.2	1903	−1.8	1892	1.6
4	1875	−1.5	1898	1.7	1886	−3.0	1900	1.8	1904	−2.0	1873	2.0	1910	−1.8	1925	1.3
5	1891	−1.4	1892	1.5	1904	−2.3	1925	1.1	1891	−1.9	1874	1.8	1920	−1.8	1878	1.2
6	1883	−1.2	1899	1.4	1889	−2.0	1877	1.1	1889	−1.6	1898	1.8	1886	−1.6	1917	1.2
7	1881	−1.2	1872	1.4	1897	−1.9	1898	0.9	1912	−1.4	1901	1.5	1891	−1.6	1911	1.0
8	1915	−1.2	1887	1.3	1915	−1.9	1901	0.9	1897	−1.3	1892	1.5	1918	−1.4	1914	1.0
9	1902	−1.1	1917	1.0	1913	−1.7	1873	0.9	1884	−1.0	1911	1.5	*1915*	−1.3	1879	0.9
1927		−2.6				−2.6				−2.9				−3.6		

No.	Jacksonville, Fla. (56 years)				Montgomery, Ala. (55 years)				Memphis, Tenn. (56 years)				New Orleans, La. (56 years)				Galveston, Tex. (57 years)			
	Cool		Warm		Cool		Warm		Cool		Warm		Cool		Warm		Cool		Warm	
	Year	Depression	Year	Excess	Year	Depression	Year	Excess	Year	Depression	Year	Excess	Year	Depression	Year	Excess	Year	Depression	Year	Excess
1	1904	−1.6	1881	2.2	1912	−1.9	1881	2.7	1903	−2.2	1881	3.5	1894	−2.5	1921	4.4	1903	−2.6	1875	3.1
2	1908	−1.4	1876	1.9	1903	−1.8	1902	2.3	1910	−2.2	1925	2.9	1879	−1.8	1919	3.5	1894	−2.4	1881	2.6
3	*1920*	*−1.3*	*1878*	*1.6*	*1910*	*−1.8*	*1877*	*2.1*	*1915*	*−2.0*	*1914*	*2.6*	1892	−1.6	1924	2.6	1904	−1.5	1876	2.3
4	1889	−1.2	1883	1.6	1884	−1.7	1878	1.6	1889	−1.9	1874	2.3	1889	−1.3	1873	2.5	1919	−1.5	1872	2.2
5	1918	−1.1	1897	1.6	1889	−1.6	1914	1.4	1904	−1.8	1921	1.9	1890	−0.9	1881	1.9	1889	−1.0	1871	2.1
6	1919	−1.1	1880	1.3	1923	−1.6	1925	1.3	1917	−1.8	1901	1.8	1904	−0.9	1915	1.9	1920	−1.0	1883	2.0
7	1921	−1.1	1914	1.2	1904	−1.4	1883	1.3	1891	−1.7	1885	1.5	1912	−0.9	1902	1.6	1892	−0.9	1878	2.0
8	1910	−1.0	1885	1.1	1894	−1.4	1875	1.3	1912	−1.7	1871	1.3	1875	−0.8	1878	1.1	1913	−0.9	1885	1.9
9	1884	−0.9	1877	1.0	1920	−1.2	1874	1.1	1920	−1.6	1918	1.3			1914	1.1			1877	1.8
10	1894	−0.9	1900	0.9	1883	−1.1	1876	1.1	1906	−1.5	1896	1.2							1884	1.3
11					1916	−1.1	1897	1.1	1882	1.4	1878	1.1							1896	0.9
12					1917	−1.1	1921	1.1	1877	−1.1	1899	1.1								
13									1892	−1.1	1909	1.1								
14	1927	0.0				−0.2				−2.3						0.8				0.7

No.	Cincinnati, Ohio (56 years)				Indianapolis, Ind. (56 years)				Chicago, Ill. (54 years)				Cheyenne, Wyo. (56 years)			
	Cool		Warm		Cool		Warm		Cool		Warm		Cool		Warm	
	Year	Depression	Year	Excess	Year	Depression	Year	Excess	Year	Depression	Year	Excess	Year	Depression	Year	Excess
1	1915	−3.0	1874	3.3	1915	−4.0	1874	4.6	1875	−4.0	1921	5.3	1915	−5.1	1881	4.9
2	1889	−2.8	1881	3.1	1889	−2.9	1873	3.3	1915	−3.7	1919	3.7	1895	−2.7	1874	3.2
3	1891	−2.7	1901	2.7	1904	−2.7	1872	3.2	1884	−3.6	1911	2.8	1906	−2.6	1873	2.8
4	1921	−2.5	1872	2.3	1903	−2.5	1901	2.9	1891	−3.4	1913	2.7	1904	−2.4	1923	2.5
5	1920	−2.0	1913	2.3	1912	−2.2	1921	2.8	1903	−3.3	1914	2.5	1908	−2.4	1919	2.4
6	1886	−1.9	1914	2.1	1917	−2.2	1871	2.4	1883	−3.0	1870	2.3	1917	−2.1	1871	2.2
7	1903	−1.9	1876	2.1	1920	−1.8	1913	2.1	1889	−2.8	1916	2.2	1872	−1.9	1879	2.2
8	1907	−1.6	1873	2.0	1924	−1.8	1881	2.1	1904	−2.8	1904	2.1	1920	−1.7	1901	1.8
9	1885	−1.5	1877	1.9	1885	−1.8	1914	2.0	1882	−2.5	1874	2.0	1875	−1.5	1922	1.7
10	1910	−1.4	1898	1.7	1902	−1.7	1919	1.9	1902	−2.3	1910	1.9	1891	−1.5	1886	1.5
11	1917	−1.4	1919	1.7	1882	−1.6	1875	1.8	1924	−2.0	1922	1.8	1912	−1.4	1900	1.5
12	1912	−1.3	1871	1.5	1910	−1.4	1887	1.3	1917	−1.8	1880	1.6	1897	−1.2	1909	1.4
13	1875	−1.2	1878	1.5	1877	−1.4	1894	1.3	1892	−1.6	1908	1.4	1907	−1.2	1910	1.2
14	1904	−1.0	1887	1.5	1891	−1.3	1895	1.3	1873	−1.6	1923	1.4	1903	−1.1		
15	1882	−0.8	1900	1.4	1884	−1.0	1899	1.3	1885	−1.6	1894	1.3				
16			1925	1.4					1888	−0.9	1899	1.3				
17	1927	−3.1				−3.9				−3.9				−2.5		

No.	Denver, Colo. (55 years)				Santa Fe N. Mex. (54 years)				Salt Lake City, Utah (53 years)				Boise, Idaho (38 years)				Portland, Oreg. (54 years)				San Francisco, Calif. (56 years)				San Diego, Calif. (57 years)			
	Cool		Warm		Cool		Warm		Cool		Warm		Cool		Warm		Cool		Warm		Cool		Warm		Cool		Warm	
	Year	Depression	Year	Excess	Year	Depression	Year	Excess	Year	Depression	Year	Excess	Year	Depression	Year	Excess	Year	Depression	Year	Excess	Year	Depression	Year	Excess	Year	Depression	Year	Excess
1	1915	−4.0	1881	3.9	1895	−2.5	1874	2.5	1907	−4.0	1919	4.6	1907	−3.2	1922	3.2	1899	−3.0	1926	4.1	1911	−2.7	1888	2.4	1879	−3.3	1871	3.3
2	1887	−3.6	1874	3.4	1908	−2.1	1879	2.0	1908	−3.4	1887	3.0	1916	−2.6	1878	2.7	1881	−2.6	1918	2.0	1901	−2.5	1925	2.3	1899	−2.3	1883	2.0
3	1904	−3.0	1892	2.9	1906	−2.0	1922	2.0	1891	−2.7	1922	2.7	1881	−2.6	1919	1.9	1893	−2.6	1889	1.7	1910	−2.4	1891	1.8	1894	−2.2	1875	1.9
4	1885	−2.9	1901	2.6	1907	−2.0	1881	1.8	1899	−2.2	1889	2.4	*1912*	−2.4	*1921*	1.9	*1880*	−2.3	*1875*	1.6	1887	−2.2	*1926*	1.7	*1916*	−2.1	*1885*	1.8
5	1891	−2.6	1922	2.3	1905	−1.9	1902	1.8	1895	−2.1	1878	2.0	1902	−2.1	1889	1.5	1901	−2.3	1915	1.6	1893	−2.1	1921	1.6	1880	−2.0	1891	1.8
6	1880	−2.5	1878	1.9	1921	−1.8	1889	1.6	1906	−2.1	1910	1.9	1880	−2.0	1918	1.4	1910	−1.6	1917	1.6	1908	−2.0	1877	1.5	1902	−1.8	1918	1.8
7	1906	−2.3	1919	1.9	1894	−1.6	1918	1.4	1880	−1.6	1918	1.9	1899	−2.0	1926	1.4	1909	−1.5	1922	1.6	1899	−1.7	1913	1.5	1892	−1.7	1925	1.7
8	1912	−2.3	1879	1.7	1911	−1.5	1917	1.3	1897	−1.6	1924	1.9	1908	−1.4	1882	1.0	1887	−1.0	1923	1.6	1871	−1.6	1922	1.5	1908	−1.6	1877	1.6
9	1908	−2.1	1900	1.6	1897	−1.4	1902	1.3	1894	−1.3	1921	1.8	1887	−1.2	1903	0.8	1890	−1.0	1925	1.6	1909	−1.6	1890	1.4	1892	−1.7	1926	1.5
10	1897	−1.6	1873	1.4	1915	−1.4	1878	1.1	1904	−1.2	1886	1.8	1911	−0.7			1900	−1.0	1906	1.4	1894	−1.5	1915	1.4	1905	−1.5	1888	1.4
11	1898	−1.5	1924	1.3	1920	−1.3	1888	1.1	1885	−1.1	1883	1.7					1895	−1.0	1888	1.1	1914	−1.4	1923	1.2	1895	−1.3	1876	1.3
12	1920	−1.2	1910	1.2	1904	−1.2	1924	1.0			1900	1.6					1902	−0.9	1920	1.1	1880	−1.3	1889	1.1	1914	−1.3	1884	1.3
13	1883	−1.1	1918	1.2	1912	−1.2	1910	0.8			1881	1.3							1924	1.1	1898	−1.3			1911	−1.2	1919	1.2
14	1923	−1.0	1893	0.9							1901	1.1							1886	1.0	1882	−1.0			1901	−1.1	1882	1.0
15																			1913	1.0			1879	1.0	1912	−1.1	1922	1.0
16																			1891	0.9					1909	−1.1		
17	1927	−2.3						0.1				0.8				0.7				2.1				2.0	1910	−1.0		1.0

COOL SUMMERS

The cool summer of 1816.—Information as to the summer of 1816 is of two sorts: First, thermometric observations made in New England and southeastern Pennsylvania, together with references to the unusual weather of that year that are found in authentic historical documents of the time; and second, the accounts, mostly by space writers, that have appeared in recent years in which the sensational aspect of the summer in question is emphasized and statements are made that can not now be proved or disproved.

A number of the details of the cool summer of 1816 that have appeared in the public prints are grossly exaggerated.

During the period of years, 1811–1817, the most remarkable depression of temperature in the summer months occurred in New England. There is not the slightest justification for claiming or assuming that the summer temperatures generally throughout the United States were unduly low. The years 1812 and 1816 were the two outstanding examples of great cooling in the summer months in New England.

An account of the cool summer of 1816, based mainly on the original observations made in Williamstown, Mass., is given by Milham (1). This is the most detailed and complete account of that unusual summer that has yet appeared in print.

Cool summers, Table. 1.—The table includes the most reliable and homogeneous pre-Weather Bureau temperature records available, viz, those of New Haven, Conn., 1813–1912, New Bedford, Mass. 1813–1912. The records of these two stations are unique in that both contain the record of the cool summer of 1816 as well as those of subsequent abnormal summer temperatures. The two western, or rather interior-valley stations of St. Paul Minn., and St. Louis, Mo., the first having a record that dates back to 1820 and the second to 1837, are the only ones in the interior that are available in this study. For New England the summer of 1816 was the coolest in more than 100 years, and this statement is confirmed by the evidence of eight other New England stations having much shorter records. All of these stations except Salem, Mass., unite in ascribing to 1816 the coolest summer in the nineteenth century; further search, however, discloses the fact that the summer of 1812 at Salem, Mass., was cooler than the 1816 summer at the same station (2). The group of years 1811–1817 in New England was remarkable in that low summer temperatures were experienced throughout. The record at Salem extends from 1786 to 1828; during this period the year 1812 was decidedly the coolest and the same is true of Cambridge, Mass., a station having a record comparable, both as to length and period of years, with that of Salem.

There are no instrumental or other reliable records that support the view that the 1816 summer was a cool one generally throughout the United States; indeed, if we are to believe the editorial that appeared in the Boston Recorder of August 7, 1816, the contrary may have been the case. The editorial comment follows:

> In relation to the season, accounts from all parts of the country present an agreeable reversal of the gloomy reports which were made a few weeks since. Fruits of every description will be abundant. All kinds of grain except corn are more promising than in ordinary seasons.

The data of Table 1 should be interpreted with the knowledge that oscillations of temperature are greatest in the interior of continents and in relatively high latitudes. St. Paul, Minn., is a good example of the large variations that occur in the interior as compared with a coastal station. The amplitude of the oscillation at that station in the 107 years of record was 11.1°, or from 5.9° below to 5.2° above the normal. At the New Haven station, near the ocean, the amplitude, including the cool summer of 1816, was but 9°, from 4.2° below to 4.8° above.

The second coolest summer.—At the long-record station of New Haven the second coolest summer occurred in 1903, 87 years later than the first, and the abnormality was within three-tenths of a degree of that of 1816. At New Bedford the summers of 1836 and 1903 were equal in coolness, but since 1836 as a whole was a very cold year, the summer of that year is given second place in relative rank.

The lowering of the summer temperature of 1903 was due, in the main, to the exceptionally low temperature of June of that year over a rather large area in the United States, viz, from southern New England southwestward to eastern New Mexico, southward to the Gulf of Mexico, and northward as far as Iowa and the lower Lake region.

In order to show graphically the relative rank of the three largest negative abnormalities at the 25 stations, I have charted them in Figure 1. Comment on that figure is unnecessary.

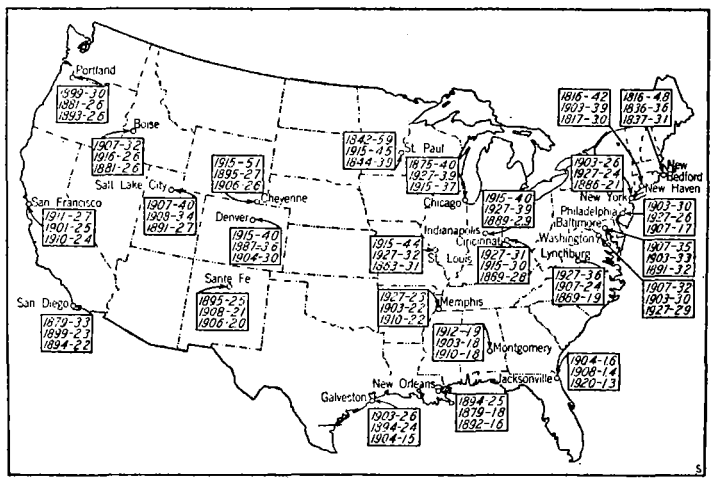

FIG. 1.

The cool summer of 1927.—The abnormality of the summer of 1927 is given for each station at the bottom of Table 1. The depression of temperature in this summer was due largely to low maxima and not to pronounced low minima.

As shown in Figure 1, it was the coolest summer in fifty-odd years at Lynchburg, Va., Memphis, Tenn., and Cincinnati, Ohio, and the second coolest at New York City, Philadelphia, Chicago, St. Louis, and Indianapolis; it was the third coolest at Washington, D. C.

At the 100-year record stations (New Haven and New Bedford) its relative rank was No. 30 and No. 32, respectively. That is to say, at New Haven there have been 29 summers since 1816 that were cooler than the summer of 1927. At New Bedford the number was 31.

Sequence of cool summers.—In order to see whether there is any massing of cool summers at periodic intervals, I have arranged the number of occurrences of first, second, and third coolest summers chronologically and present the results in Table 2. These data are defective for the period prior to the early seventies because of lack of sufficient records.

In the last fifty-odd years four summers of exceptional coolness, 1903, 1907, 1915, and 1927, have occurred. Comparing these summers it may be noticed that there is little to choose from as to which was the most conspicuous as to the depression of the temperature. Considering the length of the time the low temperature prevailed and the area affected and the minimum temperature recorded, 1915 should be given first place. Each month of that summer, including May and in a less degree September, was abnormally cool.

The greatest depression of the temperature in the summer of 1907 was in June following an exceptionally cool April and May (3).[1] The cool summer of that year may therefore be considered as a holdover effect from the cold spring immediately preceding.

The remaining three summers, 1903, 1915, and 1927, have several features in common, the most striking being the fact that each of them was preceded either in May or June by flood-producing rains in the lower Missouri Valley and adjacent territory. It may also be pointed out that the interval between these cool summers is exactly 12 years, and if we go back another 12 years to 1891 we shall find that the mean July temperature of that year was the lowest of record up to that time in a large part of the country. The flood-producing rains were, however, absent to a great extent. Whether the heavy rains are the primary cause of the cool summers or whether both events are due to a common cause is, of course, unknown. Heavy rains in the Plains States of Kansas and Nebraska and the lower Missouri Valley in May or June generally result from a checking of the progressive movement of weak cyclonic disturbances which may form over the middle Rocky Mountain and Plateau regions (4). The precipitation of May, 1903, was wide spread and exceptionally heavy in the lower Missouri Valley and the mean temperature for that month was below the normal to the southwest of the area of heavy rains. In June the area of below normal temperature had spread to the east and southeast.

From the heavy rains as above mentioned it may be inferred (1) that the vertical air temperature gradients over the region in question must have been profoundly disturbed and (2) that there must have been an unusual indraft of air from lower latitudes and its ascent and cooling in order to produce the heavy rains. The question naturally arises what was the reaction of these events upon the subsequent weather in eastern United States? There is always present the tendency to invoke the aid of cosmic causes in the explanation of terrestrial weather. In this particular year there is some ground for such action; it may be remembered that the intensity of solar radiation diminished in 1902 and 1903 (5). In February and March, 1903 a pronounced minimum in the temperature of the surface waters of the North Atlantic was observed (6). The suggestion was made that the minimum thus observed may have been due to the transportation of cold water southward by the Labrador current, but the authors were unable to determine for a certainty whether the cooling was produced by the transportation of cold water or not.

The cool summer of 1915.—The 1915 depression of temperature was unlike those of both 1903 and 1927 in that it was practically continuous from May to August, both inclusive. The locus of greatest cooling in May extended from the great valley of California across the Rocky Mountains, the Plains States to the Lake region and the lower St. Lawrence Valley. In June the entire United States, except a narrow strip along the Gulf coast and from Texas to southern California and along the Pacific was under the influence of the cooling agent. In July the conditions were practically unchanged and in August the greatest depression of the temperature (6°) was confined to the lower Missouri Valley.

An examination of the meteorological records of Canada and Alaska seems to indicate, paradoxical as it may seem, that the great depression of temperature in the United States and to a less extent in Canada had its beginnings in the excess warmth of the spring of 1915 in Alaska and Canada. April, 1915, was unduly warm, particularly in Saskatchewan, where the daily excess of temperature for the month was 12°. The high temperature of that month extended southward and included most of the United States.

In the succeeding month a reversal came, due largely to the origin of four vigorous anticyclones in close proximity to the western shore of Hudson Bay. These formations spread to the southward, carrying with them great bodies of dry cold air from the north and northeast, the effect of which apparently endured until the end of August. The locus of greatest warmth in April was in Saskatchewan, in May it was to the westward near the Pacific where it remained during June and moved slightly to the northeast in July; in August it covered the Mackenzie Basin and had encroached on United States territory to the south.

The locus of the greatest negative departures in May was close to the northern border of the United States, in June it covered the upper Missouri Valley and Wyoming, and in July it had spread slightly to the northeast; in August it was centered over the middle Mississippi and lower Missouri Valleys and wholly within the United States.

During the continuance of the cool weather in the United States and Canada, temperature in Alaska was continuously above the normal and there was a definite spread of the warmer weather southeastward in August. I am therefore inclined to reject the idea that a flow of polar air equatorward was the cause of the low temperature in the summer of 1915 unless polar air be defined as having its origin in latitude 55°–65° N.

In Europe and Asia that summer was also cool over very considerable areas and there were two projections of cool weather equatorward, the first over northwestern Europe and the second over central and southeastern Siberia toward but not including Japan.

The first half of 1915 was characterized by large fluctuations of pressure from the normal in various parts

[1] Cf. Cold Spring of 1907, A. J. Henry, MO. WEA. REV. 35:223–25.

of the Northern Hemisphere. For the benefit of those who may wish to speculate upon the relation of any one of these fluctuations to the low temperature of the summer of 1915, the table below has been prepared. The data are from Reseau Mondial, 1915.

Year and month	Deviation	Place
1915		
	mb	
January	−13.4	Dawson, Yukon Territory.
	−11.1	Dutch Harbor, Aleutian Islands.
	−15.1	Budapest, Hungary.
	−15.1	Potsdam, Germany.
	+10.7	Malye Karmakouly, Nova Zembla.
	+14.1	Verkhoiansk, Siberia.
February	−14.1	Valencia, British Isles.
	−12.1	Aberdeen, Scotland.
	+9.7	Perm, Union of Socialistic Soviet Republics.
	+8.9	Ekaterineburg, Union of Socialistic Soviet Republics.
March	−16.1	St. Johns, Newfoundland.
	−15.6	Sable Island, Atlantic Ocean.
	−12.3	Horta, Azores.
	+12.8	Angmagsalik, Greenland.
	+12.0	Upernavik, Greenland.
	+8.0	Okhotsk, Siberia.
April	−10.5	Dawson, Yukon Territory.
	−7.0	Dutch Harbor, Aleutian Islands.
	−10.0	Berufjord, Iceland.
	−7.9	Angmagsalik, Greenland.
	+7.6	Valencia, British Isles.
	+5.4	Horta, Azores.
May	−8.2	St. Johns, Newfoundland.
	−4.5	Horta, Azores.
	−4.8	Barkerville, British Columbia.
	−4.7	Prince Rupert, British Columbia.
	−5.7	Vardo, Norway.
	−4.1	Kola, Union of Socialistic Soviet Republics.
	+5.8	Thorshavn, Faroe Islands.
	+5.8	Aberdeen, Scotland.
	+6.4	Nome, Alaska.
	+3.8	Dutch Harbor, Aleutian Islands.
	+6.5	Petropavlovsk Phare, Kamchatka.
	+4.4	Nikolaevsk-sur-Amour, Siberia.

The record of the 1927 cool summer is complete, month by month, with the issue of this number of the REVIEW. The heavy rains and resulting floods of the early months of the year need not be recounted, but it is to be remembered that the effect of the rains and floods on agriculture was equal to, if not greater than, that of deficient temperature in June and August.

WARM SUMMERS

In the early part of the nineteenth century there were rather violent temperature fluctuations, cold years 1811 to 1817, and again in 1835–1837; warm years in the twenties and early thirties; thus at New Bedford the warmest summer in 100 years was in 1825, while at New Haven it was later, in 1876. Table 2 shows a group of warm summers in the seventies, extending into and apparently reaching a peak in 1881—a year with the greatest number of stations showing warm summers; 1874 comes second in this respect, and finally beginning with 1919, another series of warm summers set in but it was less extensive than the series of 1874–1881.

It is a rather common belief that any extreme in temperature or other meteorological element is more apt to be followed by one of an opposite character than by one of like character, and this tendency is well illustrated in several of the long series of records here presented, although little is found to encourage the belief that this tendency can be used in seasonal forecasting.

TABLE 2.—*Order of magnitude of cool summers and warm summers, respectively, at 25 stations in the United States*

[No. 1 stands for the absolute coolest, or warmest at the number of stations given in the table; No. 2 the next and so on]

Year	Cool			Year	Warm		
	No. 1	No. 2	No. 3		No. 1	No. 2	No. 3
1816	2			1821		1	
1817			1	1825	1		
1836		1		1830	1		
1837			1	1831		2	
1842	1			1837		1	
1844			1	1870	1		
1863		1		1872	1	1	2
1875	1	1	1	1873		1	1
1879	1	1		1874	3	2	
1881		1		1875	1		
1884			2	1876	1	2	3
1886		1	1	1877			2
1887		1		1878			1
1889		3		1879	1	1	
1891			3	1881	6	2	
1892			1	1887		1	
1893			2	1888		1	
1894	1		1	1889			1
1895	1	1		1891	1		
1897			1	1892			2
1899	1	1		1894			2
1903	4	4	1	1899		1	
1904	1		3	1900	1	2	1
1906			2	1901	1	1	1
1907	4	1		1902		1	
1908		3		1906			1
1910		2	1	1911			1
1911	1			1914			2
1912	1			1918		1	
1915	5	2	1	1919	1	2	2
1920			1	1921	2		
				1922			1
				1925	1	1	
				1926	1		1

Testing the above precept by the figures in Table 2, it will be noticed that in the series of warm summers in the seventies there were interspersed a number of cool summers. In the eighties, after 1881, warm and cool summers were about evenly divided; in the next decade of years there were more cool than warm summers and this decade must be classed as a cool one, it was followed by a group of warm summers—1899–1901—and this group of warm summers was almost immediately followed by the cool summers of 1903 and 1907.

A second series of cool summers was experienced in 1915–1917 and these were followed by the warm summers 1919–1926. The cool summer of 1927 is therefore following a precedent established by centuries of observations.

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